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STATUS OF AVAILABLE MACRO AND MICRONUTRIENTS IN THE SOILS OF SOMESHWAR WATERSHED IN ALMORA DISTRICT OF UTTARAKHAND

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ABSTRACT

A study was conducted in agricultural area of Someshwar Watershed to analyze the soil fertility, status of macro and micro-nutrients and their inter-relationship.In general the soil of the region was sandy-loam type with high organic content and acidic in nature. The surface soil (0-15 cm) was found rich in both macro- and micro- nutrients as compared to the sub-surface soil (15-30 cm). The nitrogen, phosphorus and potassium content in surface soil varied from 248-470.73, 17.8-33 and 59.2-319.2 kg/ha respectively, as compared to 147.35-488.78, 13.4-27.6 and 35- 206 kg/ha, respectively in sub-surface soil. Sodium and sulphur in the surface soil were found in the range of 12-33 and 52-112 mg/kg respectively, whereas in sub-surface soil it ranged from 7 - 27 and 51-109 mg/kg respectively. Micronutrients *i.e.*, Copper, Manganese, Zinc and Iron in the surface soil varied from 0.12-4.52, 1.2-5.9, 0.18-1.29 and 32-83.7 mg/kg, respectively as compared to 0.13-1.38, 0.3-4.7, 0.16-1.27 and 21.3-71.2 mg/kg, respectively in sub-surface soil. The inter-relationship analysis among the soil chemical properties indicated that the micro- nutrient cations were significantly correlated with each other signifying the dynamic equilibrium among them.

KEY WORDS
Macro nutrient
Micronutrient
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INTRODUCTION

Soil is a diverse complex that can be defined as a mixture of minerals and organic materials, which are capable of supporting plant life (Ayoub *et al*. 2007, Brady *et al*. 1990). Soil contains 13 out of 16 different elements essential for plant growth (Raven *et al*., 1995). However, only small amounts of nutrients are available for plants (McLean and Watson, 1985). Nutrients become available through mineral weathering and through decomposition of organic matter into inorganic mineral which are absorbed by plants in the form of ions. Soil nutrients are threatening agriculture potentials, because their availability depends on SOM content, soilpH, adsorptive surface, soil texture and nutrient interactions in the soil. Also the efforts to enhance soil macro and micronutrients are constrained by lack of up-to-date data. Hence, such kinds of interventions depend on major national soil survey information dating back to the 1980s(FAO). Millions of hectares of land worldwide are low in available micro-nutrients, and many of these deficiencies were further aggravated by the increased demands of more rapidly growing crops for available forms of micro-nutrients (Rengel, 2007, Alloway, 2008).The solubility and availability of micro-nutrients is largely influenced by clay content, pH, SOM, CEC, phosphorus level in the soil and tillage practices (Fisseha, 1992).

Soil related limitations affecting the crop productivity including nutritional disorders can be determined by evaluating the fertility status of the soils.Soil testing provides the information about the nutrient availability of the soil upon which the fertilizer recommendation for maximizing crop yield is made.Original geologic substrate and subsequent geochemical and pedogenic regimes determine the total amounts of micro- nutrients in soils. However, total amount is rarely indicative of the availability by plant, because availability depends on soil pH, organic matter content, adsorptive surfaces and other physical, chemical and biological conditions in the rhizosphere.

Plants absorb nutrients differentially from various fractions and remove their varying quantities from soil. Since different fractions of the element have different solubility and the amount of each depends on various soil characteristics. It is also important to examine the relationships of the major physical and chemical properties of soils with their available form for a better understanding of their available pool in the soil. Such information is potentially valuable in predicting bioavailability, metal leaching rates, and transformations between chemical forms in agricultural and polluted soils.Maintenance of fertility of soils is of immense concern to obtain harness higher yields.The soil fertility evaluation can forecast for suitable cropping system in the state. Considering the views cited above, an attempt was made to analyze the soil fertility, status of macro and micro-nutrients and their inter-relationship of the irrigated soils of Someshwar watershed in Almora district of Uttarakhand.

MATERIALS AND METHODS

The present investigation was carried out to assess some macro and micro-nutrient status of the soils of Someshwar agricultural watershed, Uttarakhand (India).The study area falls under Almora district of Uttarakhand state of India, located between latitude of 29º.76'N and longitude of 79º.60'E.with an average elevation of about 1430m above mean sea level. Soil was well drained with average thickness ranging from 0.1 to 0.5 m. The color of soil ranges from light to moderately dark. The average annual rainfall is about 1152 mm. The maximum and minimum humidity ranged from 66 to 98 per cent and 25 to 67 per cent, respectively. The mean maximum and minimum temperatures were found to be 28.2 and -1.2ºC, respectively. Agricultural activity is solely dependent upon seasonal rainfall in the area.

Collection and preparation of samples

Soil samples were collected from two depths (0 - 15 cm and 15 - 30 cm) from the agricultural watershed.All the composite soil samples were air-dried, ground and passed through 2 mm sieve for chemical analysis. All the samples were stored in the polythene bags for further analysis.

Analytical methods for soil samples

The soil samples were analyzed for pH, EC, OC, available N, P, K, S, DTPA extractable Fe, Mn, Zn and Cu.The analytical procedures adopted and their references are given in Table 1. Statistical analysis was done with Scientifica (7) to establish the correlation among the soil chemical properties.

Categorization of soil nutrient statusand nutrient indices

The nutrient index (NI) values for available nutrients present in the soils were calculated utilizing the formula suggested by Parker *et al.* (1951) and classified this index as low (<1.67), medium (1.67 to 2.33) and high (>2.33).

The following equation was used to calculate Nutrient Index Value

$$\text{Nutrient Index (NI)} = (N_l * 1) + (N_m * 2) + (N_h * 3)/N_t \quad \ldots\ldots\ldots (1)$$

Where

N_t = Total number of samples analyzed for a nutrient in any given area.

N_l = Number of samples falling in low category of nutrient status.

N_m = Number of samples falling in medium category of nutrient status.

N_h = Number of samples falling in high category of nutrient status.

RESULTS AND DISCUSSION

Physio-Chemical Properties

The textural class of the surface soil (0-15 cm) varied from clay, sandy loam, loam and loamy sand whereas in case of sub-surface soils (15-30 cm) it varied from clay loam, sandy clay loam , sandy loam, loam, silty clay loam and clay. In general sandy loam soil was found in the agricultural soils of Someshwar watershed. The pH value of surface soils varied from 6.1 to 6.7with a mean value of 6.4 and for sub surface soils it varied from 6.1 to 6.8 with a mean value of 6.45 respectively, which indicated that these soils are acidic in reaction with the surface soils being more acidic in nature, whereas EC of surface soil ranged from 60 to 150 μs/cm with a mean value of 105 μs/cm and of sub-surface soil from 50 to 90 μs/cm with a mean value of 70 μs/cm.The percent organic carbon content in surface soils ranged from 0.9 to 2.12 per cent with the mean value of 1.51 per cent and in subsurface soil it ranged from 0.5 to 1.2 per cent with the mean value of 0.85 per cent. The percent organic carbon content was observed to be higher in the top soil layers. This might be due to increased rate of decomposition of organic matter as concluded by Rashmi *et al.* (2009).The concentration of physical and chemical properties of surface and sub-surface soils is elaborated in Table 3 and 4, respectively.

Table 1: Details of the analytical methods followed in soil analysis

Sl.No	Soil characteristics	Method of estimation	Reference
1	pH (1: 2 soil : water)	pH meter	Jackson (1973)
2	Electrical conductivity	EC bridge	Jackson (1973)
3	Organic carbon	Walkley and Black wet oxidation method.	Jackson (1973)
4	Available N	Alkali permanganate method	Subbiah and Asija (1956)
5	Available P	Spectrophotometer method using Bray reagents.	Black (1965)
6	Available K and Na	Flame photometer method using neutral normal ammonium acetate as extractant	Jackson (1973)
7	Available S	Calcium Chloride extraction method	Williams and Steinbergs (1959)
8	DTPA extractable Fe Mn, Zn, Cu	Atomic absorption spectrophotometer method using DTPA as extractant	Lindsay and Norvell (1978)

Table 2: Rating limits for available soil nutrients

Nutrient	Low	Medium	High
N (kg/ha)	<280	280-560	> 560
P (kg/ha)	<10	10-25	>25
K (kg/ha)	<108	108-280	>280
S(mg/kg)	<10	10-20	>20
Fe (mg/kg)	<4.8	4.8-8.0	> 8.0
Mn (mg/kg)	<2	2-4	> 4
Zn (mg/kg)	<0.6	0.6-1.2	> 1.2
Cu (mg/kg)	<0.2	0.2-0.4	> 0.4
Nutrient Indices (NI)	<1.67	1.67-2.33	>2.33

Available macro and micronutrients

The available N, P, K in the surface soil ranged from 235.15 to 470.73, 16.3 to 33 and 59.2 to 319.2 kg ha^{-1} with the mean value of 352.94,24.65 and 189.2 kg ha^{-1} respectively, whereas in sub-surface soil, it ranged from 147.35 to 488.78, 13.4 to 29.70 and 35 to 153.5 kg ha^{-1} with the mean value of 318.06, 21.55 and 94.25 kg ha^{-1}respectively. A higher concentration

Table 3: Physical and chemical properties of surface soils

Soil sample	Elevation (m)	Surface soil (0-15 cm)				pH	EC	% OC
		Sand (%)	Silt (%)	Clay (%)	Texture			
S-1-A	1395.00	18.00	35.08	46.92	CLAY	6.30	70.00	0.90
S-3-A	1406.00	61.86	22.94	15.21	SANDY LOAM	6.50	150.00	1.20
S-5-A	1417.00	68.29	16.00	15.71	SANDY LOAM	6.70	70.00	1.05
S-7-A	1408.00	62.07	22.93	15.00	SANDY LOAM	6.60	90.00	1.10
S-9-A	1400.00	49.00	29.00	22.00	LOAM	6.10	60.00	1.22
S-1-B	1384.00	42.79	29.57	27.64	LOAM	6.70	110.00	0.95
S-3-B	1400.00	8.00	26.00	66.00	CLAY	6.50	120.00	1.25
S-5-B	1434.00	73.28	25.30	1.42	SANDY LOAM	6.10	90.00	1.40
S-7-B	1412.00	8.00	26.00	66.00	CLAY	6.30	70.00	1.10
S-9-B	1388.00	61.93	24.07	14.00	SANDY LOAM	6.50	110.00	0.98
S-1-C	1500.00	54.00	29.07	16.93	SANDY LOAM	6.50	80.00	1.60
S-3-C	1487.00	51.78	28.12	20.08	LOAM	6.20	70.00	1.45
S-5-C	1526.00	73.42	17.30	9.28	SANDY LOAM	6.40	50.00	1.10
S-7-C	1518.00	54.36	31.86	13.78	SANDY LOAM	6.30	70.00	0.87
S-9-C	1514.00	61.86	21.14	17.00	SANDY LOAM	6.50	110.00	1.17
S-1-D	1510.00	77.08	9.35	13.57	SANDY LOAM	6.50	120.00	2.12
S-3-D	1497.00	79.30	16.78	3.93	LOAMY SAND	6.50	70.00	1.05
S-5-D	1143.00	61.86	26.14	12.00	SANDY LOAM	6.70	90.00	1.87
S-1-E	1428.00	68.22	16.50	15.28	SANDY LOAM	6.30	70.00	2.21
S-1-F	1435.00	73.08	21.06	5.86	LOAMY SAND	6.20	70.00	2.14

Table 4: Physical and chemical properties of sub-surface soils

Soil sample	Elevation (m)	Sub- Surface soil (15-30 cm)				pH	EC	% OC
		Sand (%)	Silt (%)	Clay (%)	Texture			
S-2-A	1395	53.78	26.22	20	LOAM	6.8	70	0.53
S-4-A	1406	68.848	29.728	1.424	SANDY LOAM	6.3	70	0.95
S-6-A	1417	59.144	23.928	16.928	SANDY LOAM	6.7	70	0.98
S-8-A	1408	45.928	21.072	33.072	CLAY LOAM	6.7	70	0.75
S-10-A	1400	63.072	24	12.928	SANDY LOAM	6.7	50	0.85
S-2-B	1384	32.78	29.58	37.64	ClAYlOAM	6.2	60	0.5
S-4-B	1400	74.36	16.216	9.424	SANDY LOAM	6.4	50	0.75
S-6-B	1434	56	21.928	22.072	SANDY LOAM	6.7	70	1
S-8-B	1412	61.28	21.576	17.144	SANDY LOAM	6.8	70	0.85
S-10-B	1388	52	27.072	20.928	SANDY CLAY LOAM	6.8	90	0.52
S-2-C	1500	61.856	21.072	17.072	SANDY LOAM	6.1	60	1.1
S-4-C	1487	12.08	47.92	40	SILTY CLAY LOAM	6.1	60	0.95
S-6-C	1526	4	30	66	CLAY	6.6	70	0.56
S-8-C	1518	57	23	20	SANDY LOAM	6.2	50	0.81
S-10-C	1514	61.856	22.936	15.208	SANDY LOAM	6.4	50	0.6
S-2-D	1510	68.304	23.928	7.768	SANDY LOAM	6.5	70	1.2
S-4-D	1497	54	29.08	16.92	SANDY LOAM	6.6	80	0.99
S-6-D	1143	41.928	28.072	30	CLAY LOAM	6.7	80	0.83
S-2-E	1428	57.86	25.14	17	SANDY LOAM	6.5	70	1.03
S-2-F	1435	31.78	32.12	36.08	CLAY LOAM	6.7	50	0.99

of available nitrogen, phosphorous and potassium was found in surface soil than in sub-surface soil. Sulphur and Sodium content in the surface soils was found in the range from 52 to 112 and 11 to 33 mg $kg^{-1}$with the mean value of 82 and 22 mg kg^{-1} respectively, whereas, in the sub-surface soils, it was found in the range of 32 to 109 and 7 to 27 mg $kg^{-1}$with the mean value of 70.5 and 17 mg kg^{-1} respectively. The concentration of surface soils was more in surface soils than as in sub-surface soils.The overall concentrations of primary soil nutrients are shown in Table 5 and 6.

DTPA-Fe, Mn, Zn and Cu content in the surface soils of Someshwar watershed ranged from 30 to 83.7, 1.2 to 5.9, 0.10 to 1.29 and 0.12 to 4.52 mg kg^{-1} with a mean value 56.85, 3.55, 0.695 and 2.32 mg kg-1, respectively. In the subsurface soils DTPA-Fe, Mn, Zn and Cu content ranged from 21.3 to 71.2, 0.3 to 4.7, 0.01 to 1.29 and 0.13 to 1.38 mg kg^{-1} with a mean value of 46.25, 2.5, 0.64 and 0.75 respectively. The overall concentration of micronutrients in the soil is given in Table 7.

Correlation coefficient

The overall correlation studies between physicochemical properties and available micronutrients of the surface and subsurface soils are presented in Table (9)& (10).Positive and significant correlation coefficients were observed between elevation-Nitrogen (r=0.601**), elevation-phosphorous (r=0.636**) and elevation-iron (r=0.574**). Soil pH showed

Table 5: Concentration of primary and secondary nutrients in surface soils

Soil sample	Elevation	Concentration N (Kg/ha)	P (Kg/ha)	K (kg/ha)	Na (mg/kg)	S (mg/kg)
S-1-A	1395.00	248.15	27.80	100.80	14.00	62.00
S-3-A	1406.00	306.56	29.60	173.60	17.00	95.00
S-5-A	1417.00	380.04	28.40	319.20	15.00	98.00
S-7-A	1408.00	250.14	26.40	59.20	15.00	86.00
S-9-A	1400.00	278.25	23.20	120.00	31.00	75.00
S-1-B	1384.00	272.05	17.80	123.40	12.00	22.00
S-3-B	1400.00	310.14	22.70	117.60	14.00	110.00
S-5-B	1434.00	400.07	24.60	33.60	24.00	96.00
S-7-B	1412.00	307.28	21.50	161.60	24.00	87.00
S-9-B	1388.00	235.15	16.30	132.60	18.00	53.00
S-1-C	1500.00	500.35	31.20	210.50	27.00	105.00
S-3-C	1487.00	359.15	29.80	196.00	33.00	87.00
S-5-C	1526.00	421.15	33.00	89.60	29.00	87.00
S-7-C	1518.00	350.13	29.50	78.90	11.00	96.00
S-9-C	1514.00	458.73	27.40	111.40	15.00	63.00
S-1-D	1510.00	470.73	26.40	89.60	28.00	54.00
S-3-D	1497.00	358.15	23.40	168.00	31.00	76.00
S-5-D	1143.00	274.17	17.80	72.80	15.00	52.00
S-1-E	1428.00	350.13	28.50	84.00	32.00	112.00
S-1-F	1435.00	470.45	29.00	72.80	28.00	105.00

Table 6: Concentration of primary and secondary nutrients content in sub-surface soils

Soil sample	Elevation	Concentration N (Kg/ha)	P (Kg/ha)	K (kg/ha)	Na (mg/kg)	S (mg/kg)
S-2-A	1395	170.5	26.00	72.8	13	56
S-4-A	1406	258.19	27.50	106.4	7	62
S-6-A	1417	381.38	29.70	206	11	68
S-8-A	1408	147.35	21.50	35	11	76
S-10-A	1400	175.5	18.70	95	25	87
S-2-B	1384	273.45	16.00	33.6	9	32
S-4-B	1400	270.15	17.80	44.8	11	90
S-6-B	1434	412.28	13.20	72.8	20	87
S-8-B	1412	306.24	17.60	93.6	16	76
S-10-B	1388	225.15	15.00	71.5	16	39
S-2-C	1500	488.78	24.70	153.5	18	98
S-4-C	1487	356.23	23.20	67.2	18	71
S-6-C	1526	420.05	27.60	54.5	15	75
S-8-C	1518	348.05	22.40	62.3	10	87
S-10-C	1514	434.54	21.30	87.6	13	51
S-2-D	1510	456.45	22.30	39.2	23	67
S-4-D	1497	356.5	19.00	140	27	51
S-6-D	1143	274.12	13.40	35.7	12	57
S-2-E	1428	348.24	21.30	61.6	15	109
S-2-F	1435	468.78	21.00	95.2	21	98

negative and significant correlation with Sodium (r = -0.542*) in surface soils. Available nitrogen showed positive and significant correlation with Phosphorous (r = 0.600**), organic carbon (r = 0.474*) and sand (r=0.449*) and negative significant correlation with silt (r=-455*). Positive and significant correlation were observed between phosphorous-sulphur (r=0.616**) and phosphorous-Iron (r=0.447*). Sodium showed positive and significant correlation with organic carbon (r=0.506*). Organic carbon showed positive and significant correlation with copper (r=0.539*). Zinc also showed positive significant correlation with silt (r=0.470*).Manganese showed positive and significant correlation with sand (r=0.453*).Silt showed negative and significant correlation with sand (r=-0.627**), also sand showed negative and significant correlation with silt+clay (r=-0.963**).

Analysis of correlation of soil properties with various nutrients in sub-surface soils are given in Table-10. A positive correlation were observed between elevation-nitrogen(r=0.519*), elevation-phosphorous (r=.472*) and elevation-iron (r=.516*). Soil pH showed positive and significant correlation with Soil EC (r = 0.468*). Available nitrogen showed positive and significant correlation with organic carbon (r = 0.501*) and also with copper (r = 0.698**). Organic carbon showed positive and significant correlation with sulphur (r=0.554*) and manganese (r=0.495*). Phosphorous showed positive and significant correlation with potassium (r=0.455*). Sodium showed positive and significant correlation with

Table 7: Concentration of micronutrient in the soil

Soil sample	concentration in surface soils				Soil sample	Concentration in sub-surface soils			
	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Fe (mg/kg)		Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Fe (mg/kg)
S-1-A	0.25	0.65	2.20	32.00	S-2-A	0.42	0.58	0.9	23.2
S-3-A	0.21	0.33	5.90	47.80	S-4-A	0.24	0.16	0.3	31.5
S-5-A	1.25	0.18	5.60	33.00	S-6-A	0.24	0.39	2.4	21.3
S-7-A	0.12	0.22	3.80	59.10	S-8-A	0.22	0.16	1.27	58.2
S-9-A	0.18	0.40	2.92	56.30	S-10-A	0.24	0.38	1.06	52.3
S-1-B	0.35	0.58	1.80	33.30	S-2-B	0.53	0.55	0.9	23.5
S-3-B	0.25	0.41	1.60	53.50	S-4-B	0.21	0.01	2.3	37
S-5-B	0.65	1.29	4.30	62.00	S-6-B	0.73	1.27	3.2	42.8
S-7-B	0.36	0.16	1.20	57.20	S-8-B	0.25	0.1	0.4	37.4
S-9-B	0.16	0.56	1.58	34.50	S-10-B	0.28	0.32	0.14	21.4
S-1-C	1.25	0.70	2.11	78.40	S-2-C	1.26	0.55	0.16	71.2
S-3-C	0.08	1.25	2.43	56.80	S-4-C	0.13	0.69	1.9	52.1
S-5-C	0.63	0.47	2.08	77.40	S-6-C	1.2	0.45	1.98	71
S-7-C	0.24	0.83	2.06	83.70	S-8-C	0.84	0.76	1.6	74.3
S-9-C	0.26	0.76	1.58	66.00	S-10-C	1.25	0.72	0.11	58.9
S-1-D	1.33	0.21	3.50	54.20	S-2-D	1.38	0.14	4.7	34
S-3-D	0.09	0.10	2.30	52.00	S-4-D	0.53	0.4	0.9	47.3
S-5-D	0.17	1.18	2.60	37.50	S-6-D	1.2	0.98	1.4	31.6
S-1-E	4.52	0.46	3.80	30.00	S-2-E	1.08	0.88	3.1	23.4
S-1-F	0.12	0.61	2.50	35.80	S-2-F	1.23	0.58	1.8	22.5

Table 8: Percent samples falling in low, medium and high categories of essential nutrientsand nutrient indices (number of samples = 40)

Nutrient	Low	Medium	High	Nutrient Indices (NI)
N	14 (35)	26(65)	0	1.65 (Medium)
P	0	24 (60)	16 (40)	2.4 (Medium)
K	26 (65)	13 (32)	1(2.5)	1.375 (Medium)
S	0	0	40(100)	3.00 (High)
Fe	0	0	40 (100)	3.00 (High)
Mn	20 (50)	16 (40)	4(10)	1.60 (Medium)
Zn	26 (65)	11 (27.5)	3(7.5)	1.425 (Low)
Cu	8 (20)	14 (14)	18(45)	2.25 (Medium)

Note: Values in parenthesis are per cent soil samples.

Table 9: Simple correlation coefficient among the soil properties and available nutrients in surface soil

	pH	Ec	N	P	K	Na	OC	S	Cu	Zn	Mn	Fe	Silt	Sand	Silt+Clay
Elevt.	-.319	-.164	.601**	.636**	.134	.360	-.131	.304	.111	-.215	-.085	.574**	-.261	.209	-.156
pH		.43	-.14	-.295	.318	-.542*	-.150	-.396	-.046	-.301	.090	-.229	-.246	.079	-.008
Ec			-.114	-.294	-.044	-.443	.016	-.263	-.142	-.071	.222	-.162	-.108	-.044	.089
N				.600**	.096	.425	.474*	.349	.233	.088	.039	.431	-.455*	.449*	-.372
P					.146	.299	.150	.616**	.253	-.009	.312	.447*	-.173	.254	-.239
K						.034	-.253	.144	.011	-.303	.233	-.111	-.089	-.084	.130
Na							.506*	.297	.341	-.043	.007	.121	-.378	.344	-.276
OC								.227	.539*	.161	.178	-.213	-.441	.365	-.278
S									.328	-.062	.304	.291	-.105	.012	.023
Cu										-.136	.292	-.221	-.415	.221	-.118
Zn											-.144	.140	.470*	.066	-.242
Mn												-.227	-.374	.453*	-.404
Fe													.108	.049	-.095
Silt														-.627**	.393
Sand															-.963**

**. Correlation is significant at the 0.01 level (2-tailed);*. Correlation is significant at the 0.05 level (2-tailed).

organic carbon (r=0.459*). Silt showed negative and significant correlation with sand (r=-0.724**) and positive correlation with silt+clay (r=0.475*). Negative and significant correlation was observed between sand and silt+clay (r=-0.951**).

Soil nutrient index value

The DTPA-Zn was found low in soils whereas medium for DTPA-Mn and Cu and higher nutrient indices for DTPA Fe, according to Parker *et al.*(1951). The nutrient index values of Fe, Mn, Zn and Cu were 3.0, 1.60, 1.425 and 2.25 respectively of the agricultural soils of Someshwar watershed. Among the primary nutrients N, P, K was found to be in medium range

Table 10: Simple correlation coefficient among the soil properties and available nutrients in sub-surface soil.

	pH	Ec	N	P	K	Na	OC	S	Cu	Zn	Mn	Fe	Silt	Sand	Silt+Clay
Elevt.	-.381	-.338	.519*	.472*	.234	.293	.173	.219	.157	-.145	.133	.516*	.048	-.048	.040
pH		.468*	-.325	-.227	.033	.242	-.162	-.078	-.130	-.075	.057	-.409	-.266	.074	.025
Ec			-.212	-.149	.028	.050	-.035	-.436	-.112	-.020	-.015	-.357	.087	-.062	.041
N				.199	.309	.311	.501*	.305	.698**	.293	.341	.238	.093	-.129	.122
P					.455*	-.220	.134	.157	.016	-.278	.023	.192	.156	-.092	.047
K						.190	.374	.093	-.136	-.086	-.242	-.013	-.050	.257	-.305
Na							.459*	.201	.193	.059	.239	.102	.137	-.019	-.038
OC								.554*	.233	.062	.495*	.013	.016	.300	-.389
S									.227	.140	.381	.270	-.237	.129	-.059
Cu										.418	.286	.214	-.092	-.116	.189
Zn											.158	.074	.207	-.264	.244
Mn												-.162	-.034	-.004	.021
Fe													-.077	-.169	.250
Silt														-.724**	.475*
Sand															-.951**

with an index value of 1.65, 2.4 and 1.375 respectively. Sulphur was found high in the soils with an index value of 3. The nutrients index values are presented in Table 8.

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